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POPULAR INTEREST IN ASTRONOMY.[1]

BY J. D. GALLOWAY.

It has been, for a number of years, the custom for the retiring President of the Society to prepare a paper for the annual meeting, and following this plan, I am presenting these observations upon one phase of the subject of astronomy. The paper of the retiring President has usually taken the form of a description of the life and work of that astronomer to whom has been awarded the Bruce medal for distinguished services to astronomy. As no award of the medal has been made this year, I have been forced to select another form of subject. Belonging to that large class whose interest in the science is based upon a general knowledge only as contrasted with those familiar with its technical aspects, I must necessarily approach the subject from the popular side.

Popular interest in astronomy, while adding nothing to the increase in knowledge, either technical or general, has its value in the encouragement and help which it gives to those engaged in the actual work of study and investigation. That the necessary financial assistance be given by which facilities be provided for work of astronomers, it is required that popular interest be fostered and maintained. In most countries it is the State which supports and encourages the study of astronomy, often assisted by private gifts, such as provision for the California State Observatory by JAMES LICK, the maintenance of distant branches by D. O. MILLS or the eclipse expeditions, the expenses of which have been borne by W. H. CROCKER.

It is doubtful if there can be found a warrant for the expenditure of the money of the State for the study of astronomy in any way comparable with that by which the Legislature appropriates money for the destruction of an insect pest of a fruit tree, the protection of the bank of a river, or the prevention of forest fires: The one represents practically nothing that can be measured by that common foot rule, the dollar, while the others are of immediate and obvious value to the citizen. Yet the most superficial observation will at once make note that in this so-called material Western civilization, remote from the older centers of culture, there exist two of the greatest of the observatories, one maintained by the State and the other by private means. Here also exists one of the largest of the popular astronomical societies, furnishing an interested and appreciative audience before which the men actively engaged in astronomical work may submit the results of their labor. With these tangible evidences of popular interest, it may seem unnecessary to review the aspects of astronomy which appeal to the popular mind. It may, however, be not amiss to dwell upon some phases of the subject. There is no doubt but that the maintenance of the observatories by the people of the State and the continuance of popular interest in the subject of astronomy arises from that pride which is gratified by the support of the science and not from any great acquaintance with the subject-matter of the work of the astronomer. With this phase of the subject, it is not the intention to deal. It is sufficient to say that a citizen may cheerfully submit to his tax for the maintenance of the observatory without knowing the difference between a planet and a star. An honest pride in the results of scientific research is entirely consistent with a lack of understanding of even the ordinary details of the science.

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[1] Address of the retiring President at the annual meeting of the Society, March 30, 1912.

The popular aspects of astronomy, upon which comment is made herein, deals with that direct interest in the work of the astronomer held by a layman who follows his work year by year with an intelligent understanding of the results obtained. It is not necessary that such a person be able to follow the technical detail by which a problem is demonstrated in order to conceive of the result. We can understand when LEUSCHNER announces that a consideration of the observed orbits of comets shows them to be all ellipses, which are closed curves, that, therefore, comets must all belong to the solar system. It is not necessary for us to be able to demonstrate the various forms of an equation of the second degree in order to understand that an ellipse is a closed figure and that an hyperbola or a parabola is not. A person standing on the shore of a lake may note the number of waves beating on the shore in a given time. He knows that if he be in a boat rowing against the waves he will intercept a greater number and if rowing with the waves a lesser number in the same time interval. From analogy he can understand when CAMPBELL states that a given star is moving from or towards the Earth with a given velocity that this result is obtained by measuring the number of light waves intercepted in a given time interval. It is not necessary to understand the detail of the measurement of star spectra with the comparison spectrum of a glowing gas, or the theory of the spectrum from a grating or a prism. Such is the understanding of a popular interest in astronomy. Without criticising in any way the writers on astronomical subjects, it may be said that it is to their interest to at times translate their results into such form that the person whose technical training is limited, may form a mental concept of the result. It is believed that this can be done in most cases with direct benefit to all. It maintains the interest of the lay members of the societies and it gives a corresponding audience able to appreciate and understand the work of the astronomers.

Here I would warn those whose interest in astronomy is popular only against expecting anything sensational in astronomical discoveries. The subject is one in which sensation is entirely lacking. We are so filled to a surfeit with vulgar sensations in the every-day life around us that there may be a disappointment for one just interesting himself in astronomy in not finding a new discovery every day. It is true that some newspapers maintain an astronomical correspondent whose duty it is to announce something new and startling at regular intervals. There are also some astronomers of more or less note who find what they set out to discover—snow on the Moon,—canals on *Mars,* and so forth. No wonder that there is a popular demand to know if the planets and the stars are inhabited and just what are the crops on the planet *Mars,* which cause its ruddy color.

The easy and the obvious things have all been found out long ago. In this case, as in all others, "science moves but slowly, creeping on from point to point." Ages ago, the dwellers under the open sky observed those common aspects of the heavens which would be indeed new and startling if presented to us who shield ourselves from the sky by the roofs of houses. The constellations were named and determined, the paths of the planets laid down, the north and south movements of the Sun known, all the ordinary phenomena of the heavens observed by men of a time now lost in the distant past. What one may designate roughly as the second period of astronomy has also passed. This consisted in the giving of a correct explanation for the observed phenomena, such as that of COPERNICUS, of NEWTON, or of LA PLACE. To the men of the present time, the problem is more complex. With all the gathered results of past ages, it is their task to look forward into the future and advance their science. The astronomer of the present may say with ULYSSES that

"All experience is an arch wherethro'
Gleams that untravell'd world, whose margin fades
For ever and for ever as I move."

On the one hand the astronomer of the present must devote his lifetime to the patient observation and recording of the daily aspects of the heavens. Such work is that of AITKEN upon the double stars, the periods of which may be ten years or a hundred years. Only in a future time, when all who are now here will have passed from the stage, will the full results of such labors be known. Some astronomer of the future, as yet unborn, may, by making use of the observations now being made night after night at Mount Hamilton, be able to formulate and co-ordinate results that will settle many of the problems of celestial mechanics. This type of astronomical work, wholly without sensational aspects, is probably on the whole of the most value. The scientific method is relentless in the requirement that only by long-continued observation of phenomena can any general law be determined.

On the other hand, the modern astronomer is forced to rest his opinions upon the results of other sciences. The physical sciences are in a state of flux. Old theories are not standing the test of modern experiment. A quarter of a century ago the atom held almost undisputed sway as the unit of matter. Now we find that respectable unit surrounded by all sorts of strange forces and the solid matter which we inherited all dissolved into a world of electrons—centers of force. There are more things in heaven and earth than were dreamt of in the old philosophy. The world of the senses has had added to it invisible forces such as the Roentgen rays and other forms of radiant energy. Discovery of new elements, such as radium, containing in a minute particle an enormous concentration of energy, has disturbed the balance of the older science.

The astronomer of to-day must take into account these discoveries, for they have direct bearing on his science. Across the void between us and the Sun we know there comes light and heat. What other forms of radiant energy may also come, we do not know, but we can not assert that they may not exist, merely because we have not a sense that appreciates them as our eye perceives the effects of light. Again old problems press for solution. What is the nature of that most common and most mysterious force, gravitation? What is that medium which intervenes between the tangible forms of matter forming the universe? What is the relation between the different forms of energy—light, heat, electricity? Far out in the regions of the stars there are questions to be answered. All the universe is in motion. Under what influences and laws do the stars move? Some work has been done on this subject, notably by Boss and by CAMPBELL, but for ages the data must be accumulated before full results can be obtained.

The layman, with his interest in astronomy, must be patient and also show appreciation of the present progress being made. Sensational discoveries are few and far between. An occasional comet or the sudden burst of a new star, such as that in the constellation *Perseus* a few years ago, are all that can be expected in the way of surprises.

The accomplishments of the astronomers have been great when the difficulties are comprehended. Situated as we are on a small body troubled with a variety of motions, pulled here and there by the other planets, the problem of accurate measurements is a difficult one to solve. Our changing atmosphere adds to the obstacles to be overcome, and the more one understands the discouraging conditions under which astronomical work is carried on, the greater is the admiration for the patience and perseverance that leads some men to prefer the isolated life on some mountain top to the world struggle, where the material rewards, at least, are larger.

If, on the one hand, sensations cannot be expected in astronomy, there must be on the other an exercise of imagination on the part of astronomers who would reap the fruits of the labors so earnestly being carried on. The mere accumulation of data based upon observations is not all. There must exist a mind capable of comprehending the results as a whole in their relation to some defined plan. Such a mind must be assisted by imagination so that it can intuitively look forward to a possible result. By the proper co-ordination and assimilation of a multitude of carefully made observations to a pre-conceived idea a theory or a law may be discovered. Care must be taken to fit the theory to the observed facts and not to bend or distort the facts to serve some idea, however brilliant.

For years astronomers have been observing the motions of the stars, generally termed their proper motions. Recent years have seen practical application of the measurement of the star motion in the line of sight. The full value of such observations is not obtained unless they are assembled to such a conclusion as that which shows the Sun to be moving at a given rate towards a distant goal in the heavens, with the planets describing gigantic helices through space while on their way. The late SIMON NEWCOMB was of the type of mind that could generalize the results of observations and deduce therefrom comprehensive and unified conclusions.

If, then, the sensational is debarred from astronomy, what appeal can the science make to the ubiquitous person whom we rarely meet, the average man? What charm can Urania offer which will overcome the constant high-pitched calls upon his attention made by the modern world? Business, politics, wars, murders, divorce, all the distractions of modern life, offer a never ending source of sensation, and amidst it all the clear voice of the muse calling from some distant mountain top is lost. Astronomy offers a long list of great discoveries in the past to interest the ordinary man, and the performance of the past is a guarantee of the promise of the future. He would indeed be rash who would say that the era of great discoveries was past. I believe that some one once uttered the doleful statement that of the constitution of the Sun and stars nothing would ever be known. Shortly after came the invention of the spectroscope, rendering it possible to determine not only the constitution of the distant objects by the analysis of the radiant light, but also furnishing a means of measuring the velocity of the moving star. I have indicated above some of the yet to be solved problems of nature. The study of the structure of the sidereal universe may throw light on the formation of world systems. The vast numbers of nebulæ seem to offer an analogy to this, but, for one, I am impressed with the idea that more knowledge must be gained before an exact understanding of the evolution of worlds is obtained. The physicist and the mathematician must join with the astronomer in the interpretation of natural phenomena. Mention of the mathematician in this connection recalls Lord BACON, who in a chapter of the *Novum Organum* pauses to remark that "therefore astronomy, as it now stands, loses its dignity by being reckoned among the mathematical arts, for it ought in justice to make the most noble part of physics." Those astronomers who have a predeliction towards mathematical astronomy should take notice and mend their ways.

The man whose interest in astronomy is general only can also find much to arouse his curiosity in the ordinary phenomena of the solar system. To reach a correct understanding of the everyday occurrences is worth study. The spectacle of the changes of the seasons, the paths of the planets through the heavens, the march of the stars, together with such occasional visitors as comets, all repay investigation. The ordinary man can approach this subject as did those men of old whose first feeling of wonder insensibly led to the investigation of things seen until the science was born. He can with the ancients observe a planet, tracing its epicyclic path on the heavens and thus realize the broad mind of the Polish monk, who by substituting simplicity for complexity, explained the problem that had baffled the best minds of all time. He can, after making the acquaintance of the members of the solar family, of which we are a part, leave the restricted confines of that system and with an untrammelled imagination, penetrate into the depths of space, conscious that however far he may roam, there will be always something beyond.

I come now to that result from the advance of the science of astronomy, which is of the greatest service to mankind—the development and enlargement of men's minds. It were an idle task to review the various achievements of the race in its rise from barbarism to civilization. The aspirations of humanity—the desire to leave some enduring trace or to benefit mankind—have found expression in various forms—in architecture or in engineering, in government or religion, in science or poetry, and in art. Such expressions may take the form of enduring monuments or may exist only in the realm of ideas. However, when one reviews the material records of past ages, it must be confessed that the total is a meager one as compared with the amount of human effort expended throughout the ages. Some vast piles of stone or ruined buildings on the banks of the Nile, a lonely temple on a Grecian hill, or some broken columns in a Roman forum, a few great cathedrals on the banks of the Seine or the Thames,—these are all that antiquity has given to us of all the labors of the past. In the realm of intellectual attainment, there is preserved the labors and discoveries of all time. Not at a uniform rate has progress been made, for at times the human mind has seemed to stand still or to retrograde. The net result has, however, been an advance from ignorance to enlightenment, from darkness to light.

The human mind, in the presence of nature, is forced to make an explanation of the wonders that surround it. Progress is slow at first, for of the obvious facts of nature, the savage always has an explanation. The gods which men have made in their own image have afforded sufficient explanation for natural phenomena to most minds. Now and then there happens along some individual to whom the common explanation does not suffice, who thereupon makes an independent investigation and perhaps sets a new mark ahead. There is a commonly received idea that primitive man beheld the universe around him in a state of constant wonder and inquiry. Nothing can be farther from the truth. The movements of the planets and the aspects of the stars are the grandest spectacles that man can witness when the magnitude of the process is understood. Yet to the savage there is nothing strange. The stars are familiar things, men have climbed up into them from the tops of high mountains; the new Moon is caused by the coyote taking a bite out of it. Even among the Egyptians and Greeks the explanations of celestial phenomena were puerile. Primitive man does not wonder, for the most trivial explanation is sufficient and that is always forthcoming.

In the long course of years, however, the minds which have not been satisfied with anything but the truth have gradually unfolded the correct explanation of natural phenomena. The darkness of the old anthropocentric conception of the universe disappeared in the light of the science that showed the true relation of the Earth to the universe. From the days of COPERNICUS to the present, we count but a short time as compared with the time interval of world history, yet in that period the universe has been found to be of an extent of which no human mind can form a conception. He who now looks up at the heavens with only the information which any one can obtain, gazes at a scene the magnitude of which can not be appreciated even in symbolism. The mind can not appreciate the huge globe upon which we live—can not form in thought an idea of the distance to the Sun or planets, and if an attempt is made to pass to the stars it turns back upon itself baffled, as when trying to fix the boundaries of time or of space. Yet the astronomer, using the messengers sent to us by the distant worlds can determine their constitution and their motion and by comparison with known results ascertain that the same laws of nature hold good there as here on this Earth. For the trivial concepts of the ancients of a limited universe subject to the caprice of man-made gods, the modern astronomer has substituted a vast cosmos where law and order reign supreme. For the satisfied individual of the past, secure in his hypotheses which explained nothing, there now appears the intelligent modern man of the civilized world endowed with an understanding of the real nature of his surroundings and equipped with a mind receptive to new discoveries. Though much remains to be discovered, that which is known is secure. For him, indeed, standing in comprehending wonder at night beneath the stars, the universe becomes religion and the unknown creative element is dimly seen.

This, then, is the sum total of the benefits to humanity rendered by astronomy up to the present and to which the astronomy of the future will contribute yet again. It has done more to enlarge men's minds than any other of the sciences. Proceeding without sensation and rejecting everything but that which could stand the test of reason, astronomy has been ever in search of that truth which known will set men free. The mind that clearly holds a conception of the true relation of man to the universe has developed to a point where all the varied activities of life can be clearly grasped. He who finds law and order in the visible universe will attempt to institute law and order as the guiding of his life.

One final thought in this connection deserves comment. There has been on the part of some writers a tendency to belittle the position of man in his relation to the universe as gradually the confines of that universe were enlarged, finally to an infinite distance. The old anthropocentric conception was amazing in its effrontery, and when in the light of science it was overthrown, it apparently left man humbled into the dust. His insignificance seemed measured in the ratio to the distance to the stars. As the concept of the cosmos grew, man decreased to a vanishing point, and he may, in his unthinking moments have exclaimed, as did old OMAR in his despair at not finding the hand that worked behind the veil. To this I can not subscribe. It is my contention that all the revelations of astronomy have but served to elevate and ennoble mankind. The ignorance of the ancients did not in any way elevate their position, but rather the intellect that can now behold with comprehension a storm on the Sun or the slow revolution of two distant stars around their center of gravity or the formation of worlds from the nebulous dust of the heavens is not belittled by mere physical comparison of size. In the light of reason, comparative magnitudes vanish. Thus developed, the mind of man becomes perhaps a part of that supreme intelligence of which the visible universe is but a symbol before the limited intellect of the star-gazer. Viewed in this way, the researches of the astronomers have, by enlarging the intelligence, added immeasurably to the nobility and the dignity of mankind.